

The Effects of Creative Problem-Solving Learning Model on Students' Mathematical Problem-Solving Ability: Meta-Analysis

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ABSTRACT

The Creative Problem Solving (CPS) learning model is often used as an alternative learning model that is considered to be able to improve students' mathematical problem-solving abilities. Therefore, many studies have related to the effect of the Creative Problem Solving (CPS) learning model on the mathematical problem-solving ability of students in Indonesia. The purpose of this study is to synthesize primary studies in the form of national journal articles or national proceedings with inclusion criteria: published in 2013-2022; articles published in national journals or national proceedings or indexed by SINTA; articles with experimental or quasi-experimental methods involving the experimental group and the control class; articles that include statistical data (sample size, mean value, standard deviation). The results of the study found that the overall effect size was 0.655 in the high effect category. Analysis of the level of variation in the study was carried out by considering two moderating variables, namely education level and sample size. The difference in education level was obtained ($Q = 0.075$ and $p > 0.005$), and the difference in sample size was obtained ($Q = 2.329$ and $p > 0.005$), which did not change the effect size of the implementation of the *Creative Problem Solving* (CPS) learning model on students' mathematical problem-solving abilities.

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1. INTRODUCTION

Mathematics is a subject that plays an essential role in the world of education, which is very closely related to everyday life. James and James (1976) in (Rahmah, 2018) explain that mathematics is a science that teaches much about the role of logic in thinking, discussing various forms and abstractions and alluding to the magnitudes and concepts that empirically shape the human experience of the world. To be able to achieve some of the objectives of learning mathematics with the

intended, many abilities can be developed in learning mathematics, among others, (1) mathematical communication skills, (2) mathematical reasoning abilities, (3) mathematical problem-solving abilities, and (4) connection skills mathematics (Parnabhakti & Ulfa, 2020; Sugilar, 2017). Among some of these mathematical abilities, one of them is math problem-solving skills that students need to develop well because their role is considered meaningful and becomes the basis for the ability to master mathematics from several other mathematical abilities.

Problem-solving ability is a person's expertise or skill in solving a problem. In an effort to solve all the problems, mathematical problem-solving skills often involve a focused mindset in perfecting the strategies that have been studied in mathematics directly to find specific solutions (Mawaddah & Anisah, 2015; Widjajanti, 2009). There are four main steps in the math problem-solving activity. It means understanding the problem, planning to solve it, solving the problem as planned, and evaluating every step that is taken. To be able to develop mathematical problem-solving skills, of course, a method, strategy or learning model is needed that can trigger it appropriately, and one alternative is to use the Creative Problem Solving (CPS) learning model.

In the Creative Problem Solving (CPS) model, all learning activities focus on classroom activities and improving problem-solving skills, accompanied by enhancing other skills, including enhancing students' creative ideas (Harefa et al., 2020). By applying the Creative Problem Solving (CPS) model, students are expected to be more fun and more dynamic in solving problems using their creative ideas and intelligence development (Asikin & Pujiadi, 2008).

Much research has been done on the Creative Problem Solving (CPS) learning model and the application of mathematical problem-solving skills, including previous research on the effects of Creative Problem Solving (CPS) learning models on some math skills using meta-analysis methods, then also research conducted by Nugroho et al., (2020) influence of inquiry-based learning model and environment on mathematical problem-solving ability in meta-analytic research, as well as research conducted by Yustinaningrum (2021) in the context of a meta-analysis on the impact of *problem-based* model learning on mathematical problem-solving skills. Based on this description, studies on the effects of Creative Problem Solving (CPS) learning models on mathematical problem-solving skills using meta-analysis methods have been published in national journals and national proceedings, including several heterogeneous primary studies. It wasn't something that unfolded and evolved. Existing one-complete research. Previously, the problem formulation in this study was based on how the implementation of the Creative Problem Solving (CPS) learning model affects students' mathematics problem-solving skills and then how this affects the educational level. The question was whether there was a difference in the effect of the samples. The size of the Creative Problem Solving (CPS) learning model students' mathematical problem-solving abilities were analyzed using meta-analysis methods. It is an analytical technique for concluding different studies collected at universities by synthesizing the results of previous research papers discussing a particular topic. Topic Implementing is the big Effects of Creative Problem Solving (CPS) learning models on students' mathematical problem-solving ability (Alkausar, Lasmana, & Soemarsono, 2020).

2. METHODS

This study was a meta-analytical study and was either analytically reviewed or indexed by multiple articles in national journals or national procedures or by SINTA to provide an accurate overview of the research content of the primary studies articles are synthesized (Wardhani, 2019). The studies analyzed in this study relate to the effects of *Creative Problem Solving* (CPS) learning models on students' mathematical problem-solving abilities. Cooper, 1982 (Juandi & Tamur, 2020) explains that, in general, the steps taken in the meta-analysis are 5 stages, including; (1) defining the research problem; (2) performing data collection; (3) performing coding on all research articles that have been determined; (4) perform statistical analysis; and (5) presenting the research results.

The inclusion criteria used in this study were: (1) articles published in the last 10 years for the period 2013-2022; (2) Articles published in national journals or national proceedings or articles indexed

by SINTA; (3) articles that use experimental or quasi-experimental research methods involving one experimental class applying the CPS model and one control class using conventional models or other learning models; (4) articles that include statistical data (sample size, mean, and standard deviation).

In this research, we searched articles in the SINTA database, Google Scholar, Garuda Portal, and DOAJ, and collected data by obtaining related research articles using the keywords "CPS learning model" and "mathematical problem-solving ability." rice field. In the search process, he found 57 articles that were examined for research purposes, then tested their feasibility to be analyzed according to the inclusion criteria and produced 20 articles suitable for use in this study, including research from (Evendi, 2019; F, 2013; Fitri et al., 2020; Fitriana & Albab, 2022; Handayani et al., 2022; Harefa et al., 2020; Harman, 2018; Herlawan & Hadija, 2017; Huzayfah, 2017; Lestari & Sofyan, 2013; Muhammad et al., 2018; Neni et al., 2021; Partayasa et al., 2020; Purwati, 2015; Putri et al., 2022; Rosselyne et al., 2020; Sopian & Afriansyah, 2017; Widodo & Kartikasari, 2017; Zulyadaini, nd). Table 1 describes information about the 20 articles that will be analyzed in this study.

Table 1. List of articles used in the study

No.	Code	Author	Journal/ Proceedings
1.	KPM 01	Guntur Maulana Muhammad, Ari Septian, Mastika Insani Sofa	Moshrafa: Journal of Mathematics Education Vol. 7 No. 3, 2018
2.	KPM 02	Herlawan, Hadija	JP3M: Journal of Mathematics Education and Teaching Research Vol.3 No.1, 2017
3.	KPM 03	Novia Eka Putri, Zulyadaini, Volawati	Phi: Journal of Mathematics Education Vol. 3 No. 2, 2019
4.	KPM 04	Hanif Evendi	Proceedings of the National Seminar & Call For Papers, Master of Mathematics Education Study Program, Siliwangi University Tasikmalaya, January 2019: 218-224
5.	KPM 05	Teguh Panji Lestari, Deddy Sofyan	Moshrafa: Journal of Mathematics Education Vol. 2 No. 3, 2013
6.	KPM 06	Yopi Ahmad Sopian, Ekasatya Aldila Afriansyah	Elements Journal Vol. 3 No. 1, 2017
7.	KPM 07	Muhammad Syazali	Al-Jabar: Journal of Mathematics Education Vol. 6 No. 1, 2015
8.	KPM 08	Wayan Partayasa I Gusti Putu Suharta I Nengah Suparta	JNPM (National Journal of Mathematics Education) Vol. 4 No. 1, 2020
9.	KPM 09	Neni Syaiful Maison	AKSIOMA: Journal of Mathematics Education Study Program Vol. 10 No. 4, 2021
10.	KPM 10	Amalia, NF	Kreano's Journal Vol. 4 No. 2, 2013
11.	KPM 11	Zulyadaini	Dikdaya Scientific Journal Vol. 7 No. 1, 2017
12.	KPM 12	Moch Gustiana Sulaeman Nia Jusniani	Mathema Journal Vol. 3 No. 1, 2021

Erma Monariska			
13.	KPM 13	Roselyne Ellis Salsabila Dwi Antari Wijayanti	JRPMS (Journal of School Mathematics Learning Research) Vol. 4 N0. 2, 2020
14.	KPM 14	Harman	Dikdaya Scientific Journal Vol. 8 No. 2, 2018
15.	KPM 15	Diyah Ayu Fitriana Muhtarom Irkham Ulil Albab	Imaginary: Journal of Mathematics and Mathematics Education Vol. 4 No. 4, 2022
16.	KPM 16	Purwati	JIEM: Scientific Journal of Mathematics Education Vol. 1 No.1, 2015
17.	KPM 17	Evie Dwi Handayani Emah Kusnawati Nenden Mutiara Sari Poppy Yaniawati Muhammad Iskandar Zulkarnaen	Algebra: Journal of Mathematics Education Vol. 13 No.1, 2022
18.	KPM 18	Siti Huzayfah	Journal of Basic Education Innovation Vol. 2 No. 2, 2017
19.	KPM 19	Suprih Widodo Kartikasari	PRISMA Journal of Suryakencana University Vol. 6 No. 1, 2017
20.	KPM 20	Wiva Rahmadona Fitri Wedra Aprison Isnaniah	Math Education Journal Vol. 4 No.1, 2020

Table 1 states the identity of each primary study in the form of the code for each primary study which was analyzed using the code prefixing the letter KPM followed by the number of the primary studies included, then mentioning the name of the author of each study and the journal or proceedings that published the article along with the volume, number and year of publication. Borenstein et al. (2009) in (Paloloang et al., 2020) describe the study procedures used in the meta-analysis were (a) to calculate the effect size for each primary study; (b) to perform heterogeneity tests and estimation model selection; (c) check for publication bias. (d) calculate *p-values* to test research hypotheses. In performing these statistical calculations assisted by using *Comprehensive Meta-Analysis* (CMA) software V.03 and using Hedges's Equation based on Cohen's classification (Tamur et al., 2021) in determining the effect size index in this study, which is less than or equal to 0.2 (small effect), from 0.21 to 0.50 (medium effect), from 0.51 to 1.00 (high effect), and more than 1.00 (very high effect).

Heterogeneity tests are performed by looking at the Q statistic and the *p-value*. If the *p-value* < 0.05, the effect size for each study is heterogeneous. After determining that the estimators chosen were *random-effects models*. If the *p-value* > 0.05, then the effect size of each study is homogeneous. An analysis of the study's level of variation by examining the moderator variable was carried out after it was determined that the chosen estimate was a *random effect model*.

The next check is a publication bias test performed to avoid errors in results. Alternatively, studies with too high effects typically skew the combined effect upwards and may indicate overrepresentation (Juandi & Tamur, 2020; Paloloang et al., 2020). To overcome this tendency, funnel graphs are used to assess the degree of bias that may exist, but this study assumes that effect sizes are symmetrically distributed on the vertical line representing the combined effect size. If so, it is labeled as bias tolerant or unbiased. Represents a funnel plot. Then, if the funnel plot results are not very

symmetrical, use the *Fail-Safe-N* (FSN) test to assess the effects of existing biases. If $FSN/(5k+10) > 1$, where k is the number of primary studies, the study is said to be resistant to publication bias.

3. FINDINGS AND DISCUSSION

3.1 Statistical Data

The purpose of this study was to determine the overall effect of implementing a Creative Problem Solving (CPS) learning model on students' mathematics problem-solving skills, was to determine the effectiveness of the learning model implementation. Problem-solving skills are based on education level and sample size. Some of these studies include statistical data (sample size, mean, standard deviation) for each experimental and control class. The data are presented in Table 2.

Table 2. Statistical Data of Research Samples

No.	Citation	Experiment Class			Control Class		
		mean	SD	N	mean	SD	N
1.	Muhammad, Septian, & Sofa, 2018	0.622	0.105	24	0.233	0.285	20
2.	Herlawan & Hadija, 2017	0.53	0.25	25	0.21	0.14	25
3.	Putri, Zulyadaini, & Volunteers, 2019	63	21.71	34	53.66	22.01	35
4.	Evendi, 2019	61.19	9.93	30	58.41	9.17	30
5.	Lestari & Sofyan, 2013	0.571	0.151	35	0.459	0.184	36
6.	Sopian & Afriansyah, 2017	27.34	4.8	38	24.08	3.69	36
7.	Syazali, 2015	22.463	2.73	41	20.25	3.64	40
8.	Partayasa, Suharta & Suparta, 2020	76.26	11.24	27	65.11	12.22	27
9.	Neni, Syaiful, & Maison, 2021	20.2	6.6	34	18.2	4.5	32
10.	NF, 2013	74.31	9.88	35	72.73	12.91	37
11.	Zulyadaini, 2017	70.13	9.134852	40	62.42	10.4069	38
12.	Sulaiman, Jusniani, & Monariska, 2021	36.28	7.24	36	36.47	4.09	36
13.	Rosselyne, Salsabila, & Wijayanti, 2020	61.529	15.5451	34	53.79	15.7745	34
14.	Harman, 2018	71.9	9.66	40	63.3	9.07	40
15.	Fitriana, Muhtarom, & Albab, 2022	81.5	15.02	30	80.7	16.85	30
16.	Purwati, 2015	58,4722	18.1525	18	36,125	8.9028	20
17.	Handayani et al., 2022	47.72	18.32	42	38.1	19.69	42
18.	Huzayfah, 2017	77.64	5.47	28	71.21	4.54	28
19.	Widodo & Kartikasari, 2017	24.4	11.61	26	23.3	8.28	25
20.	Fitri, Aprison, & Isnaniah, 2020	71.82	15.6	34	61.61	17.86	36

Based on Table 2, All primary studies included in this study provide complete statistical data, i.e. mean, sample size and standard deviation values for both experimental and control classes. All of these are used in the first analysis phase, i.e., the calculation of each first-order effect size. The results of the analysis are shown in Table 3.

Table 3. Effect Size of Each Study

No.	Citation	Effect Size	Category	Standard Error	Lower limit	Upper limit
1.	Muhammad, Septian, & Sofa, 2018	1,847	Very high effect	0.357	1,148	2,546
2.	Herlawan & Hadija, 2017	1.555	Very high effect	0.319	0.930	2,180
3.	Putri, Zulyadaini, & Volunteers, 2019	0.422	Medium effect	0.241	-0.050	0.894
4.	Evendi, 2019	0.287	Medium effect	0.256	-0.215	0.789
5.	Lestari & Sofyan, 2013	0.657	High effect	0.241	0.185	1,130
6.	Sopian & Afriansyah, 2017	0.751	High effect	0.238	0.284	1.218
7.	Syazali, 2015	0.682	High effect	0.227	0.238	1,127
8.	Partayasa, Suharta & Suparta, 2020	0.936	High effect	0.283	0.381	1,491
9.	Neni, Syaiful, & Maison, 2021	0.348	Medium effect	0.245	-0.133	0.829
10.	NF, 2013	0.135	Small effect	0.234	-0.322	0.593
11.	Zulyadaini, 2017	0.781	High effect	0.233	0.325	1,237
12.	Sulaiman, Jusniani, & Monariska, 2021	0.489	Medium effect	0.243	0.011	0.966
13.	Rosselyne, Salsabila, & Wijayanti, 2020	0.909	High effect	0.233	0.453	1,365
14.	Harman, 2018	0.049	Small effect	0.255	-0.450	0.549
15.	Fitriana, Muhtarom, & Albab, 2022	1,557	Very high effect	0.365	0.842	2,272
16.	Purwati, 2015	0.501	Medium effect	0.220	0.071	0.932
17.	Handayani et al., 2022	1,261	Very high effect	0.289	0.694	1,828
18.	Huzayfah, 2017	0.107	Small effect	0.276	-0.434	0.648
19.	Widodo & Kartikasari, 2017	0.601	High effect	0.242	0.127	1.075
20.	Fitri, Aprison, & Isnaniah, 2020	-0.032	Small effect	0.233	-0.489	0.425
Combined Effect		0.655	High effect			

Based on Table 3, the overall range of effect sizes is -0.032 to 1.847 with 95% confidence intervals. Looking at Cohen's effect size taxonomy, four of his studies showed very high effect sizes, including studies in number 1, number 2, number 15, and number 17, followed by his seven major studies, i.e., studies number 5, which had higher effect sizes number 6, number 7, number 8, number 11, number 13, and number 19, five primary studies, with intermediate effect sizes in studies in number 3, number 4, number 9, number 12, and number 16, Four primary studies had effect sizes. The smaller ones are in studies in number 10, number 14, number 18, and number 20, with a total study effect size of 0.655, which is included in the high effect size category.

The next step is to test for heterogeneity and select the estimation model presented in Table 4.

Table 4. Comparison of Results Based on the Estimation Model

No	Estimation Model	n	Z	P	Effect Size	95% CL		Qb	p-value	I-squared
						Lower limit	Upper limit			
1.	Fixed-effect	20	10,662	0.000	0.606	0.494	0.717	60,316	0.000	68,499
2.	random-effect	20	6,412	0.000	0.655	0.455	0.855			

Based on Table 4, it is known that the value of *Qb* is 60.316, and the value of *p* is 0.000. This indicates that the effect size is heterogeneous with $p < 0.05$. It can also be seen in the effect size variance of the *I – squared* value of 68.499, which shows that 68% of the variance in the observed effect size has variability due to actual heterogeneity. Since homogeneity is rejected, the estimation model used in this analysis is a *random effect model*.

The next stage is to conduct a publication bias test. Figure 1 shows the results of the funnel plot in this study.

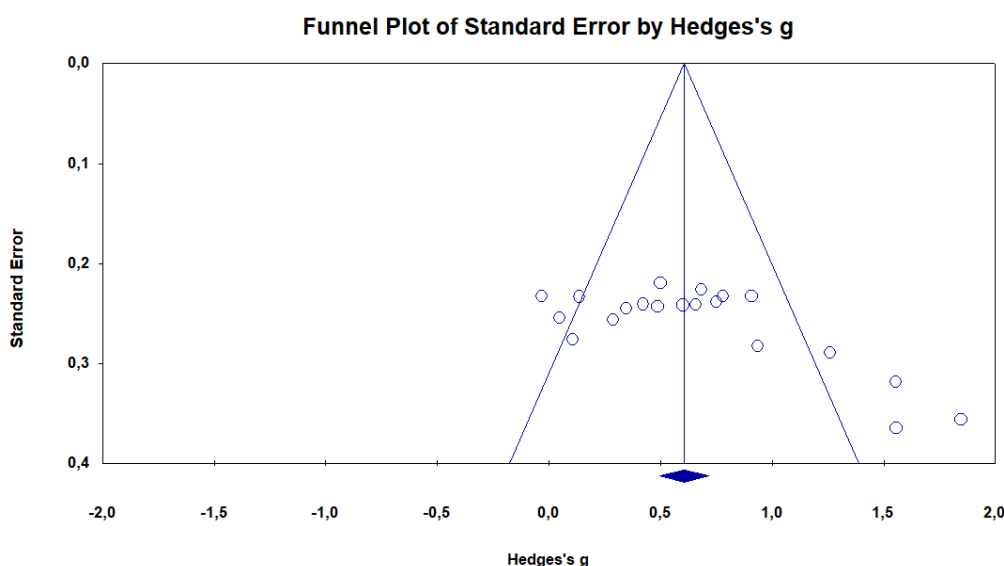


Figure 1. Research Funnel Plot

Figure 1 shows that the distribution of effects along the vertical line is not symmetrical, which can lead to subjective assessments. Therefore, in order to be able to confirm the results of the publication bias test, a fail-safe N (FSN) test should be performed. Statistical calculations in Comprehensive Meta-Analysis (CMA) resulted in an N value of 637. $637 / (5 * 20 + 10)$ yields $5.79 > 1$. That is, all studies used in this study are resistant to publication bias. Therefore, studies should not be reduced or included in the analysis due to publication bias.

The final step is to test the research hypothesis by testing the *p-value*. Table 4 shows that the 95% confidence intervals for the *random-effects model* lie between 0.455 and 0.855, indicating that mean differences are likely between these ranges effect. A z-score of 6.412 was obtained based on a z-test calculation to determine statistical significance. These results are said to be $p < 0.005$ is statistically significant. Therefore, using the *Creative Problem Solving (CPS)* learning model has a greater positive impact on students' math problem-solving skills than other learning models.

Since learning is known to be heterogeneous, it is necessary to analyze the characteristics of learning that contribute to the heterogeneity in students' mathematical problem-solving abilities. Table 5 shows the results of a meta-analysis of study characteristics, education level and sample size.

Table 5. Results of Meta-Analysis of Study Characteristics

Study Characteristics	Category	n	Hedges's g	Test of null		Heterogeneity		
				Z - value	P - value	Q - value	df(Q)	P - value
	SMA	10	0.630	5,604	0.000			
Level of education	SMP	8	0.691	3,413	0.001	0.075	2	0.963
	SD	2	0.681	1.180	0.238			
Sample Size	30 or less	8	0.922	3,683	0.000			
	31 or more	12	0.521	6,578	0.000	2,329	1	0.127

3.2 Level of education

According to Table 5 above, the effect size analysis result of 0.630 (high effect) for the high school level study is not significantly different from the effect size of 0.691 (high effect) for the middle school level study. 0.681 (highly effective) at the primary school level. Heterogeneity test results showed that the mean effect sizes did not differ across education levels ($Q = 0.075$ and $p > 0.005$). This is consistent with research conducted by (Yustinaningrum, 2021), who showed in his work that the impact of problem-based learning models has a tremendous impact on all educational levels, but (Yunita, Juandi, Hasanah, & Tamur, 2021), found that the effectiveness of project-based learning models was significantly more effective at the secondary education level compared to other educational levels. Mean effect size across education level groups from the effects of *Creative Problem-Solving* (CPS) learning models.

3.3 Sample Size

Based on the sample sizes in Table 5, we found an effect size for this study of 0.922 (high effect) for 1 to 30 students and 0.521 (high effect) for a sample size of 31 students. The results of the heterogeneity test showed no difference in the mean effect sizes of the two groups ($Q = 2.329$ and $p > 0.005$). In line with research conducted by (Susanti et al., 2020) In his study, he found no significant difference in sample size regarding the effect of problem-based learning on the mathematical communication skills of middle school students. (Tamur et al., 2020) His study found that effect sizes had very high effects with sample sizes of 1 to 30 students compared to sample sizes of 31 or more students in the RME study in Indonesia. And its implementation for the future in meta-analytic studies. Therefore, the results of the analysis of studies indicate that differences in study sample size do not alter the magnitude of effects in studies comparing *Creative Problem-Solving* (CPS) learning models with other learning models applied to learning models to students' mathematical problem solving abilities.

The results show an overall effect size of 0.655 for the study, indicating that learning by applying the *Creative Problem Solving* (CPS) learning model was significantly better than learning with conventional or other learning models. , which explains the highly positive effect on students' math problem-solving skills. These results also support research conducted by (Asikin & Pujiadi, 2008). The

study found that learning using the *Creative Problem Solving* (CPS) interactive learning model can stimulate students to impart a wide range of high-level knowledge and improve performance outcomes.

We find that there is no significant difference in the interpretation of achieved effect sizes or high effect sizes based on level of education. This highlights that the Creative Problem Solving (CPS) learning model is viable and viable at all school levels. Based on the sample size, the results obtained show that effect sizes obtained from small groups have greater effects than implementing creative problem-solving (CPS) learning models on large groups, Both are still in the process of interpreting high effect sizes and none of these could give the impression that large groups need to be included in the study to implement the model.

4. CONCLUSION

The result of an analysis of 20 articles discussing the effects of *Creative Problem-Solving* (CPS) learning models on students' mathematical problem-solving skills yielded a combined effect size of 0.655 for primary studies, a high effect underlying Cohen's classification. It can be provided with the information that it contains categories. Therefore, we can conclude that applying the Creative Problem Solving (CPS) learning model positively impacts students' mathematical problem-solving skills compared to implementing other learning models. Based on the analysis of characteristics, differences in education level and sample size were shown not to change study effect sizes. Therefore, the Creative Problem Solving (CPS) learning model is viable and can be applied to different sample sizes of mathematics learning at all educational levels to improve students' mathematical problem-solving skills. This study includes only 20 primary studies. The authors suggest conducting further studies, including many primary studies, using more diverse study characteristics, and using a broader data collection.

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